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Developing ChemFin™, a Miniature Biogeochemical Sensor Payload for Gliders, Profilers, and other AUVs

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LONG-TERM GOALS

The first goal of this project involves the further development and transition of ChemFIN™, a prototype autonomous profiling sensor for chemicals and biomolecules, into a commercial product that can be readily deployed on fixed or mobile ocean observation platforms such as coastal gliders, profiling moorings, and propeller driven unmanned underwater vehicles (UUVs). The second goal of this project is to integrate a flow immunosensor technology, developed by researchers at the Naval Research Laboratory, into ChemFIN for the detection of biomolecules of interest, such as specific biotoxins (i.e saxitoxin) that are released during harmful algal blooms (HABs). ChemFIN is being developed for sustained, autonomous ocean observations of specific chemical and biochemical distributions and spatial and temporal variability. ChemFIN is an evolving compact sensor payload, utilizing microfluidics, and is particularly designed for "low-power" underway measurements on gliders, propeller-driven autonomous underwater vehicles (AUVs) and autonomous profilers.

OBJECTIVES

The first objective is to use recent advances in micro-fluidics and optical detectors to improve the ChemFIN sensor. The technical improvements involve reducing sample flow rates and volumes and thus reagent and power consumption, extending the length of field deployments by developing new technologies to suppress bio-fouling, increasing the ease of use by simplifying operation, pre-packaging reagents and thoroughly documenting the performance by conducting demonstration experiments in coastal waters. The second objective is to adapt and integrate the flow immunosensor analytical technology, developed by NRL researchers, into the MARCHEM and ChemFIN sensors.

APPROACH AND WORKPLAN

These objectives will be achieved through a partnership between industry (Alfred Hanson, SubChem Systems, Inc.) and government (Anne Kusterbeck, NRL). The two partners have prior experience working together to develop and test new biological/chemical sensing and deployment systems. During this project, the industry partner will take the lead in developing and testing the commercial versions of the MARCHEM and ChemFIN sensors while the government partner will take the lead in the development of alternative analytical technologies for the flow immunosensor application and assistance with the testing and performance evaluation.

WORK COMPLETED

A project kick-off meeting was held at SubChem Systems for the exchange of technological information and planning for the project. Design work was continued by SubChem Systems on a new submersible chemical analyzer. ChemFIN^{TM} (Figure 1) is a small independent sensor payload, utilizing microfluidics, and is particularly designed for "low-power" underway measurements on gliders, propeller-driven AUVs and autonomous profilers. Design work and info-exchange discussions with NRL focused on integrating the NRL Flow Immunosensor technology into the MarChem and ChemFIN Analyzers. A prototype high-sensitivity, optical fluorescence detector was designed, fabricated and delivered to NRL for testing and evaluation.

NRL initiated work to develop an immunoassay for saxitoxin to be incorporated into the biosensor payload. For these assays, antibodies will be produced both as standard monoclonal antibodies (mAb) and as single domain antibodies (sdA) isolated from llamas.

RESULTS

An engineering design-path was identified and initiated for the further incorporation of the flow immunosensor technology into the MarCHEM and ChemFIN analyzers. The testing and evaluation of a specialized, user-friendly, reagent cartridge, and multiple designs for ChemFIN's micro-fluidic manifold, provided results that will allow further advancement of the technology in coming months. The new prototype optical detector for the flow immunosensor performed as well as or better than a commercial laboratory instrument.

The appropriate conjugates needed to develop antibodies were identified and synthesized in collaboration with Dr. Sherwood Hall (US FDA). These conjugates were based on hapten-carrier formats in which the hapten molecule (saxitoxin) is coupled to a carrier compound, such as Bovine Serum Albumin (BSA) at various ratios, generally 16 to 35 hapten molecules per BSA. The first injection series has been completed, with results expected in 2-3 months.

IMPACT/APPLICATIONS

The oceanographic community does not currently have the capability to make routine and sustained biogeochemical measurements, *in situ* and autonomously, at the same space and time scales that are possible for temperature, salinity, oxygen, and chlorophyll fluorescence. In recent years, though, there has been significant progress in the development and application of reagent-based optical chemical sensors. The on-going research for this NOPP project is giving us the opportunity to further develop, improve and demonstrate these autonomous chemical sensing technologies. These efforts represent

substantial advancements in the development of this technology and bring us much closer to a demonstrated capability for sustained, autonomous ocean observations of biogeochemical distributions and variability.

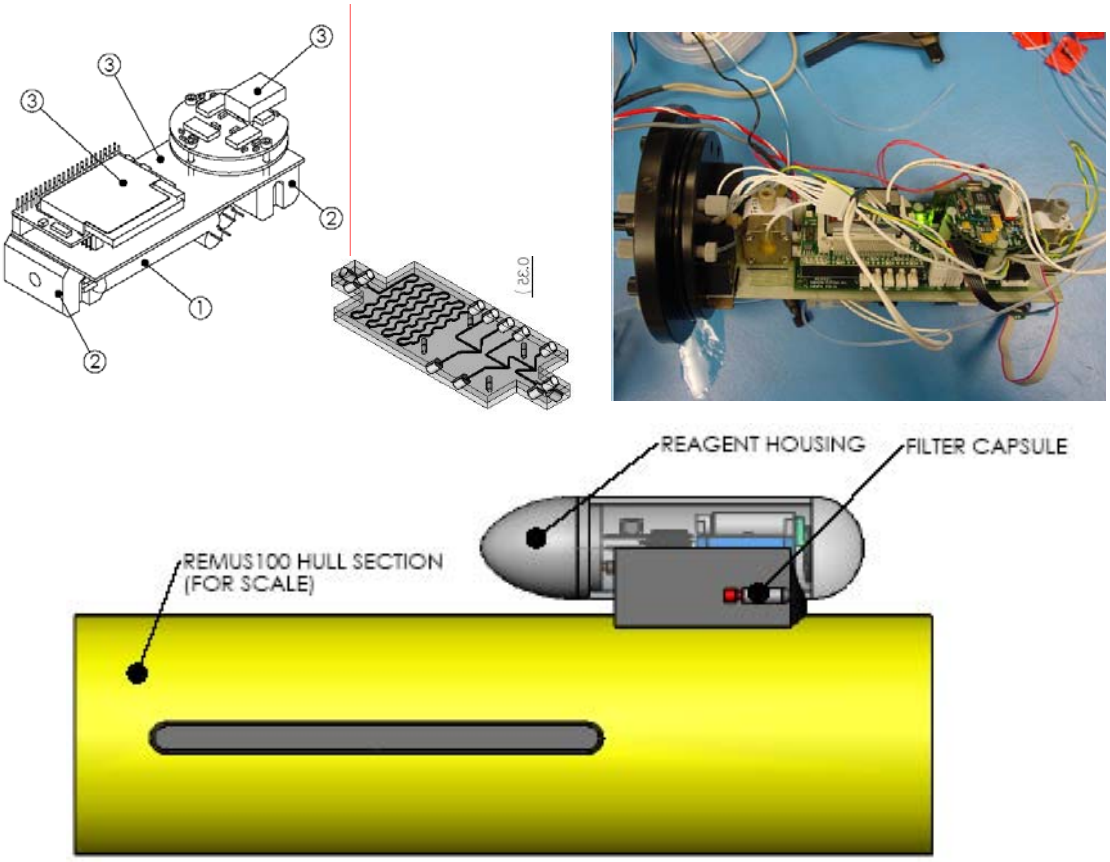

Figure 1. SubChem Systems's compact design for ChemFIN™ the next generation chemical sensing payload for AUVs, Gliders and Profilers. The ChemFIN compact microfluidics(1), optical detection(2) and electronics(3) systems (left) and housing (right) externally mounted onto a REMUS vehicle hull section.
[The ChemFIN™ is designed as an independent compact payload containing a micro-fluidic chemical analyzer that minimizes the power and space demands on the AUV platform.]